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ABSTRACT

This document summarizes a report that analyzes the issues affecting the participation of women and minorities in science and engineering. The report makes recommendations for governors, state agencies, and state educational institutions on how such participation can be increased. The current lack of women and minorities in science and engineering is a critical issue facing the nation. The special needs of these groups must be addressed on the elementary/secondary level as well as the university level. Governors can play a key leadership role in increasing awareness. State agencies and state education departments can undertake a variety of activities based on the following objectives: (1) improve the study of mathematics and science for all students and provide programs targeted at women and underrepresented minorities; (2) improve the ability of students to transfer from two-year community colleges to engineering programs; (3) promote the development of undergraduate minority engineering programs to improve the academic performance and graduation rates of minority students; (4) encourage the establishment and expansion of programs that specifically encourage more women to pursue careers in engineering; (5) develop programs to improve faculty awareness of the needs of women and minority students at both the college and precollege level; (6) hold educational institutions accountable for increasing the number of women and minority students who complete engineering degrees; (7) incorporate the goal of increasing the number of women and minority engineers into state science and technology programs. The table of contents of the full report is included. (FMW)

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NATIONAL GOVERNORS' ASSOCIATION

State Policy Reports

Capital Resources Policy Studies

Economic Development, Science and Technology Program

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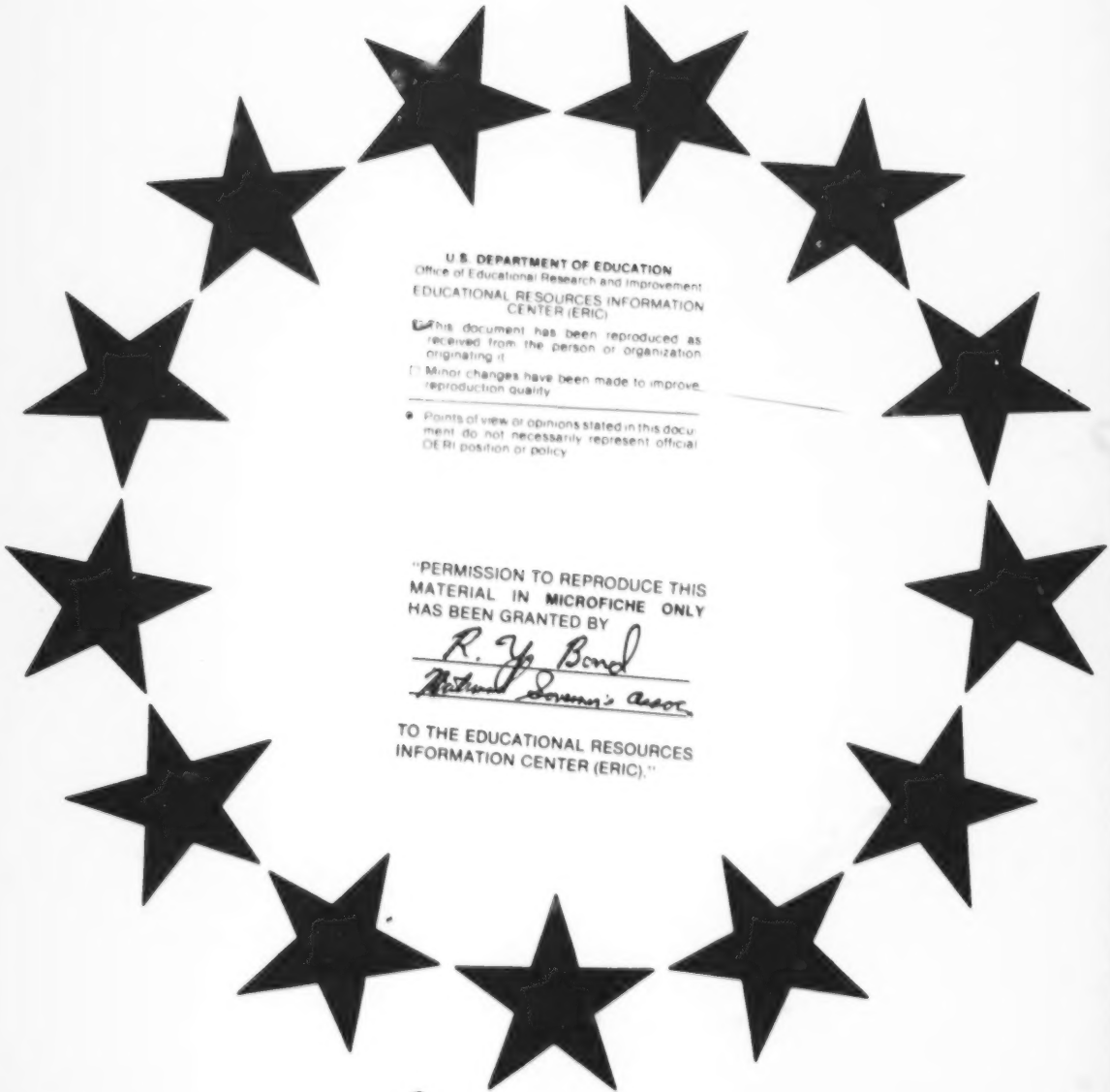

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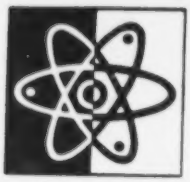

INCREASING THE SUPPLY OF WOMEN AND MINORITY ENGINEERS: AN AGENDA FOR STATE ACTION

NATIONAL GOVERNORS' ASSOCIATION

State Policy Reports

Capital Resources Policy Studies

Economic Development, Science and Technology Program

by Jean McDonald, Marianne K. Clarke, and Eric N. Dobson

Capital Resources Policy Studies
Center for Policy Research

National Governors' Association

The National Governors' Association, founded in 1908 as the National Governors' Conference, is the instrument through which the nation's Governors collectively influence the development and implementation of national policy and apply creative leadership to state issues. The association's members are the Governors of the fifty states, the commonwealths of the Northern Mariana Islands and Puerto Rico, and the territories of American Samoa, Guam, and the Virgin Islands. The association has seven standing committees on major issues: Agriculture and Rural Development; Economic Development and Technological Innovation; Energy and Environment; Human Resources; International Trade and Foreign Relations; Justice and Public Safety; and Transportation, Commerce, and Communications. Subcommittees and task forces that focus on principal concerns of the Governors operate within this framework.

The association works closely with the administration and Congress on state-federal policy issues through its offices in the Hall of the States in Washington, D.C. The association serves as a vehicle for sharing knowledge of innovative programs among the states and provides technical assistance and consultant services to Governors on a wide range of management and policy issues.

The Center for Policy Research is the research and development arm of NGA. The center is a vehicle for sharing knowledge about innovative state activities, exploring the impact of federal initiatives on state government, and providing technical assistance to states. The center works in a number of policy fields, including agriculture, economic development, education, environment, health, social services, training and employment, trade, and transportation.

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Contents

Preface	v
Acknowledgements	vii
Executive Summary	ix
INTRODUCTION	1
TRENDS AFFECTING THE FUTURE SUPPLY OF ENGINEERING STUDENTS	3
Declining College-Age Population	3
Decreasing Proportion of White Male Students	3
Increasing Proportion of Female Students	4
Decreasing Minority Enrollment	5
Increasing Numbers of Minority Engineering Students	6
Continuing High Attrition Among Minority Students	6
Declining Student Interest in Engineering	7
Conclusion	7
SYSTEMIC BARRIERS TO THE PARTICIPATION OF WOMEN AND MINORITIES IN ENGINEERING	9
Lack of Preparation at the Precollege Level	9
Type of College Attended	13
Lack of Campus Support for Minority Students	14
Inadequate Financial Resources	15
Harassment	15
Traditional Faculty Attitudes and Expectations	16
The Engineering College Environment	18
WHAT WORKS AT THE STATE AND LOCAL LEVEL	19
What Works—Precollegiate	19
What Works—Recruitment	20
What Works—Campus Support	21
What Works—Within the Engineering College	22
THE GOVERNOR'S ROLE	23
STATE ACTION AGENDA	25
CONCLUSION	29
Appendix A: State Initiatives	31
Appendix B: Women and Minorities in Engineering Project Advisory Committee	41
Endnotes	45
References	49

Preface

In 1989 the National Governors' Association (NGA) embarked on a study to identify short-term actions that could be taken by Governors to increase the number of women and minorities entering and completing engineering degree programs. The initiative was undertaken in concert with the National Science Foundation (NSF), which also provided financial support. Specifically, the project was designed to identify successful intervention strategies and to translate the lessons learned from these model approaches into a state action agenda.

Governors from the following states appointed representatives to serve on a Women and Minorities in Engineering Project Advisory Committee: California, Iowa, Michigan, Mississippi, New Mexico, New York, North Carolina, Ohio, and Texas. Members of the advisory committee are listed in Appendix B.

Four papers on exemplary programs were commissioned. These papers are contained in the recent NGA publication, *Realizing the Potential of Women and Minorities in Engineering: Four Perspectives from the Field*. Information on current state initiatives was collected and is contained in Appendix A.

This report analyzes the issues affecting the participation of women and minorities in science and engineering. It also presents recommendations for Governors, state agencies, and state educational institutions on how such participation can be increased.

Acknowledgements

The National Governors' Association wishes to thank the many individuals who contributed time and information for the development of this report. First and foremost, thanks are due to the state officials who served as members of the Women and Minorities in Engineering Project Advisory Committee.

Thanks also are due to Dale Draper and Sue Kemnitzer of the National Science Foundation for their input and support. Expert advice and guidance were provided by Raymond Landis, Dean of Engineering and Technology, California State University, Los Angeles; Jane Daniels, Director of the Women in Engineering Program at Purdue University; Paul Parker, Florida State Board of Community Colleges; and Minnie McGee, Assistant Dean, Ohio State University.

Finally, a number of NGA staff contributed to the effort. Barry Van Lare, Deputy Executive Director, carefully reviewed the draft report and provided valuable comments. Jean McDonald, Senior Policy Analyst in Education, conducted the background research and data analysis. Marianne K. Clarke, Program Director for Economic Development, Science and Technology, managed the project. Eric Dobson, Senior Staff Assistant with the Economic Development, Science and Technology Program, compiled the information on state initiatives. Karen Glass edited the report, and Raquel Stanton provided expert secretarial support. Their contributions are gratefully acknowledged.

Executive Summary

American engineers and scientists have always been among the nation's greatest assets; their work has led to world leadership in scientific and technological innovation. Recent trends are disturbing. There is concern over the quality of science and technical education at the elementary, secondary, and college levels. American high school students lag behind those of other industrialized countries, according to the National Assessment of Educational Progress' *The Science Report Card*. At the doctorate level, half of all graduate students in science are foreign nationals. To be economically competitive at home and abroad, the United States must have scientists and engineers who can keep the nation at the forefront of technological development. The supply of engineers is of particular concern because of the pivotal role they play in bringing new technologies to market.

The congressional Task Force on Women, Minorities, and the Handicapped in Science and Technology reports that by the year 2010, the United States could suffer a shortfall of as many as 560,000 science and engineering professionals. Shortages in personnel already have been felt in United States colleges and universities. The National Academy of Engineering reports that about 1,300 engineering faculty positions (or 8.8 percent of the total) were vacant in 1985. In addition, many of the scientists and engineers recruited in the 1950s in response to the launch of Sputnik are expected to retire in the early 1990s. The National Science Foundation projects that jobs for engineers in private industry will increase from 1.2 million in 1986 to almost 1.7 million in the year 2000.

Although enrollments in engineering increased from the mid-1970s to the mid-1980s, a number of trends indicate that the United States may have difficulty in meeting future demands for engineers. First, interest in pursuing an engineering degree has declined. In 1983 11.4 percent of all freshman students indicated an interest in majoring in engineering. By 1989 only 10 percent expressed such an interest. First-year engineering enrollments fell 17 percent between fall 1982 and fall 1989.

Second, the traditional pool of engineering students, which is overwhelmingly white males, is declining due to a number of demographic trends. These include a decline in the college-age population and an increase in the proportion of women and minorities in this population. Women constitute less than 4 percent of all engineers; blacks and other minorities also constitute less than 4 percent. Yet by the year 2010 one in every three eighteen-year-olds will be black or Hispanic, compared with one in five in 1985.

Figures on women and minority participation in engineering programs are disheartening. Black students receive 2.9 percent of undergraduate engineering degrees, while Hispanic students comprise 2.4 percent of engineering baccalaureates. Although female enrollments in engineering increased from 3 percent to 16 percent between 1975 and 1985, total female enrollments now are declining.

The third factor that will affect the nation's ability to meet future engineering personnel needs is students' ability to complete engineering programs. A strong

fundamental base in mathematics and science is a prerequisite to pursuing an engineering degree. Many students enter college without the necessary math and science skills. Changes must occur at the precollege level to ensure a supply of students with the necessary skills to complete a rigorous engineering curriculum.

To meet the need for engineering personnel, it will be necessary to better prepare all students in math and science, to attract more students into engineering, especially women and underrepresented minorities (blacks, Hispañics, and Native Americans), and to assist women and minorities who enter engineering to complete their degrees.

Intervention Strategies

Programs to encourage women and minorities to pursue and complete engineering degrees have been in place since the 1970s. In 1973 the National Academy of Engineering sponsored a symposium that kicked off the national minority engineering effort. A network of regional precollege programs to improve the math and science preparation of minority youth was established. Engineering colleges set up minority engineering programs to improve the academic performance and graduation rates of minority engineering students. Engineering colleges also established recruitment and retention programs for women in engineering. Much can be learned from these successful models regarding the barriers that prevent minorities and women from completing degrees in engineering and ways to overcome these barriers.

Precollege Programs. One of the major reasons underrepresented groups do not major in engineering is that they lack the necessary academic preparation and achievement. Poor academic preparation results from a variety of factors, including weak science and math curriculums in elementary and secondary schools, teachers ill-equipped to teach math and science, and a lack of course options and laboratory equipment in inner-city and rural schools. Low expectations of these students' performance held by their parents and teachers often are a self-fulfilling prophecy.

This problem is compounded when children are placed in classrooms or are assigned to teachers based on ability at an early age. For example, as early as middle school, a substantial number of minority students are placed in or choose non-academic tracks that make them ineligible for higher mathematics and science courses. Female students often are discouraged from high achievement in math and science and from pursuing male-dominated careers such as engineering.

Changes in curriculum and evaluation methods are needed to remove the artificial filters that deny students access to a quality education in science and mathematics. The filters must be replaced with pumps (i.e., programs and well-prepared teachers that promote and support the learning of mathematics and science for all students).

To successfully remove barriers to the participation of women and minorities in science and math, intervention must begin early, starting in elementary school. Parents must be involved, and positive role models must be provided. Supplementary activities to promote an interest in and understanding of science, such as Saturday schools or summer camps, are useful components of a successful strategy to increase

the number of students in the pipeline. The most effective programs have a strong academic focus.

Programs to attract young women into math and science must offer support to counteract the social pressures that may discourage young girls from pursuing math- or science-related interests. They also must encourage young women to strive for greater achievement in mathematics and science. The attitudes of teachers and counselors can be particularly influential in encouraging or discouraging female students to pursue math and science interests.

Undergraduate Programs. High dropout rates, lack of preparation, and the failure of able students to enroll in college, in part due to financial constraints, limit the number of minority students entering college. In addition, a large percentage of minorities who attend college enroll at community colleges that do not offer engineering courses. Even if the two-year college offers the prerequisite courses, transferring credit to a four-year engineering college often is difficult.

Minority students who enroll in engineering colleges face a number of barriers, including a lack of role models, lack of appropriate support services, and low faculty expectations. The engineering college environment is geared toward white males, and despite recent attempts to establish special programs for underrepresented groups, women and minorities may feel isolated and lack peer support.

Fewer than one-third of the universities with accredited undergraduate engineering programs have formal minority engineering programs; about one-third have women in engineering programs. The most effective programs focus on shaping women and minority students into an academic community and promoting a high level of collaborative learning.

Equally important are efforts to train faculty to be effective as academic advisers, mentors, and teachers of women and minority students. While existing approaches to fostering such behavior have been replicated, implementation has not been widespread.

The Governor's Role

Over the past five years, the nation's Governors have waged an aggressive campaign to improve the nation's education system. In February 1990 they adopted a set of national education goals that includes the goal of being first in the world in math and science achievement by the year 2000. Within their own states, Governors have promoted programs to require additional teacher training in basic science and mathematics, and have established highly competitive scientific secondary schools. They also have stressed more performance measurement, greater accountability, and more parental choice.

Governors can play a leadership role in encouraging the participation of women and minorities not only in engineering, but also in scientific and technical fields generally. Specifically, Governors can:

- Support education reform aimed at improving K-12 math and science education for all students.

- Provide programs targeted to women and underrepresented minorities.
- Work with the private sector to increase awareness among parents, teachers, counselors, and students of opportunities in math and science and of the importance of math and science to the future competitiveness of U.S. businesses.
- Serve as advocates for the establishment and expansion of programs that encourage more women and minorities to pursue careers in science and engineering.
- Encourage colleges of engineering to implement minorities and women in engineering programs through funding decisions and incentives.
- Provide incentives to engineering schools that reward faculty for activities enhancing the educational experience of women and minority students.
- Form a statewide cooperative effort to link organizations and individuals involved in efforts to increase the numbers of women and minorities who receive the education, encouragement, and financial support they need to pursue a career in science or engineering.
- Support the involvement of women and minorities in state science and technology programs.

State Action Agenda

State agencies and state education institutions can undertake a variety of activities at the precollege, undergraduate, and graduate levels to make students aware of opportunities in science and engineering, to prepare women and minorities to pursue advanced engineering degrees, and to improve graduation rates for women and minorities in engineering. A successful intervention strategy should incorporate the following objectives.

Improve the study of mathematics and science in grades K-12 for all students, and provide programs targeted to women and underrepresented minorities. Any effort to increase the number of students entering engineering programs will depend on the ability of the public school system to provide students with a strong foundation in basic mathematics and science. States should:

- Improve math and science teaching at the elementary and secondary levels by creating incentives to attract teachers to these subject areas, strengthening teacher preparation in both content and practical experience, and offering continuing professional development and support in these subjects.
- Support programs designed to interest young women and minorities in math, science, and engineering, and to prepare them to enter college.
- Eliminate the tracking of students by ability to ensure that all students are taught advanced math and science skills.

- Allow alternative certification to enable practicing or retired scientists and engineers to teach math and science at the K-12 level.
- Provide incentives to promote collaboration among elementary and secondary schools and engineering, mathematics, and science faculty.

Improve the ability of students to transfer from two-year community colleges to engineering programs. About half of the women and minority students enrolled in college attend community colleges. If underrepresented groups are to be recruited or prepared to enroll in colleges of engineering, steps must be taken to facilitate the flow of students from community colleges to such colleges. To achieve this goal states should:

- Promote strengthened articulation (i.e., coordination of educational institutions to ensure that students are able to transfer credits) between two-year and four-year schools by developing transfer agreements and dual admission programs.
- Establish a statewide articulation coordinating committee to encourage programmatic articulation, monitor agreements, and adjudicate conflicts.
- Encourage colleges and universities to appoint articulation officers or liaison persons to help recruit students from community colleges and to help alleviate adjustment problems of transfer students.
- Create incentives for universities to work with community colleges and/or public four-year colleges with large minority enrollments through exchange programs, campus visitations, and orientation programs for transfer students.
- Encourage community colleges to strengthen their math and science programs to be more compatible with those of four-year schools.

Promote the development of undergraduate minority engineering programs to improve the academic performance and graduation rates of minority engineering students. Of the 270 universities in the United States with accredited undergraduate engineering programs, it is estimated that fewer than 100 have established programs to improve the academic performance and retention of minority students. These programs differ in level of effort and effectiveness. Much is known about the elements of programs that help students succeed. States should:

- Create challenge or incentive grants to encourage colleges of engineering and departments of mathematics and the sciences to develop recruitment and retention programs.
- Reward effective programs and encourage their replication.
- Encourage colleges of engineering and departments of mathematics and the sciences to engage in partnerships with the private sector. Seed money or incentives may be needed to initiate such efforts.
- Provide increased financial aid to minority engineering students so they will not be required to work excessively and can devote their full-time effort to engineering study.

Encourage the establishment and expansion of programs that specifically encourage mor women to pursue careers in engineering. Women comprise about half of the populatio of every state in the nation. They are the most underrepresented, but also the mos accessible, human resource available to meet the projected shortages of engineerin talent for the future. To better utilize this resource, states should:

- Initiate or increase financial support to existing women in engineerin programs at state colleges and universities, and offer incentives to in dustries to support these programs.
- Reward effective programs and encourage their replication.
- Develop state scholarship programs to encourage young women to choos engineering as a major.
- Encourage state colleges and universities to use multiple admission criteri in addition to standardized test scores. The use of standardized test score especially math scores, eliminates large numbers of women from the poo of potential engineering students.

Develop programs to improve faculty awareness of the needs of women and minorit students at both the college and precollege level. Faculty have a key role to play i increasing the number and proportion of women and minority engineering students Engineering faculty, the vast majority of whom are white males and increasingl foreign-born, may not be sensitive to the problems experienced by female an minority students. States should:

- Provide funding to train engineering faculty to be effective in their roles a academic advisers, mentors, and teachers of women and minority students and to have higher expectations of these students.
- Support statewide implementation of programs aimed at educational equi ty, including training to help elementary and secondary teachers under stand the cultural and sex-biased expectations they bring to the classroom
- Provide incentives for universities to reward faculty for activities, such a mentoring and advising, that enhance the educational experience o women and minority students.
- Provide incentives for engineering schools to increase the representation of minorities on their faculty.
- Fund a program to support substantial loans to resident women and minority graduate students to pursue doctoral degrees in the sciences and engineering, with a forgiveness clause for faculty service at an in-state institution.

Hold schools and colleges and universities accountable for increasing the number of women and minority students who complete engineering degrees. In their efforts to encourage widespread application of proven approaches, states should:

- Collect enrollment and graduation data on groups of students who are involved in precollege or undergraduate programs as well as for all stu-

dents. This information can be used to help inform policy and to identify effective intervention approaches.

- Encourage the Accreditation Board of Engineering and Technology (ABET) to consider a college's success in enrolling and graduating women and minorities when the agency grants college of engineering accreditation.

Incorporate the goal of increasing the number of women and minority engineers into state science and technology programs. States have built an impressive track record in technology development and commercialization. State support for applied research and the establishment of advanced technology centers is encouraging more market-driven research and influencing university researchers. Such programs provide opportunities for student participation. States should:

- Require state-funded advanced technology centers or centers of excellence to incorporate activities in support of women and minority engineering students.
- Provide incentives to encourage the participation of women and minorities in state-funded research projects.
- Include women and minorities on public/private boards established to oversee state science and technology policy.

Conclusion

The current lack of women and minorities in science and engineering is a critical issue facing the nation. Since the 1970s policies and programs have been established to recruit and retain women and minorities in engineering degree programs. While a number of programs have proven highly successful, these efforts have been fragmented and implementation has not been widespread.

Changes are needed at the K-12 level to ensure that all students receive high quality instruction in math and science. The current emphasis on improving math and science education provides an opportunity to incorporate into proposed education reform the goal of improving the participation of women and minorities. Governors have actively supported education reform. Addressing the special needs of women and minorities should be included in any strategy to achieve the goal of being first in the world in math and science achievement by the year 2000.

Although efforts to improve K-12 science and math education are necessary, this approach will not be sufficient. Universities must do a better job of retaining and graduating women and minority engineering students. Of those students who enter college wellprepared in math and science, women and minorities are less likely to complete their degrees. Currently, only one in three minority students who begin the study of engineering ever graduates. Engineering colleges must recognize the specific needs of minorities and women and take steps to change the white-male-dominated culture that exists on most campuses. Engineering faculty and administrators should be held accountable for policies and attitudes that discourage women and minority students.

Governors can play a key leadership role in increasing awareness of the critic need to enable more women and minorities to pursue technical degrees. Howeve they will want to work in conjunction with school systems, colleges and universitie and the private sector. Working together, it will be possible to ensure that all studen receive the education needed to meet the demands of the twenty-first century.